Outline # 1 Introduction **ESS 315/POE 313**

What is Environmental Geology?

-The study of the functioning of Earth systems and how they affect and are affected by human activities.

Assessing 30 years "Thinking Green"
-are we making progress?

Earth Systems and Cycles

What is a system?

-structured set of objects (components) which are interconnected (related and operate together) to one another.

-any portion of the universe that can be isolated from the rest of the universe for the purpose of observing changes

Types of Systems

-isolated systems
-closed systems
-open systems

In open systems **linkages** between components cause mutual adjustments **(feedback)** between components. As one variable affects a second variable, the second variable causes a change in the first variable.

negative feedback (self-regulation) vs positive feedback (snowball effect).

Earth Cycles (Cycling provides stability in a system)
Energy, Hydrologic, Carbon, Tectonic

Human Component (Population Dynamics)
-Linear vs exponential growth
-Population Doubling Time (Rule of 70) 70 / growth rate (%)
-Total Fertility Rate (TFR): average number of children born to a woman of child-bearing years

Outline #2 Earthquakes & Seismic Risks **ESS 315/POE 313**

What are Earthquakes?
- **movement along faults**
- **elastic-rebound theory**

Seismic Waves
- **P-waves (compressional)**
- **S-waves (shear)**
- **surface waves**

Locating the Epicenter of Earthquakes
Earthquake Magnitude and Intensity

Tectonic Controls

What Causes Damages?
- **Direct Causes:** 1. ground shaking, 2. fault rupture, 3. subsidence and uplift.
- **Indirect Causes:** 1. Landslides, 2. Liquefaction, Fires, and Tsunamis

Seismic Hazards and the Cascadia Subduction Zone
- What is the Cascadia Subduction Zone?
- Earthquake activity along the Cascadia Subduction Zone
- Seismic risks along the Cascadia Subduction Zone

Historic Earthquakes (Case studies)
- Northridge, CA (1994)
- Kobe, Japan (1995)
- Mexico City, Mexico (1985)
- Loma Prieta, CA (1989)
- Izmit, Turkey (1999)
- Indonesia (2004)

Earthquake Prediction?
- statistical methods
- geophysical methods
- geological methods

Earthquake Prevention?
- high pressure fluid injections

Preparedness and Mitigation
- seismic zoning and urban planning guidelines
- building codes, improving structural designs of buildings and highways
- geologic mapping to locate faults
- public education

Outline #3 Volcanic Hazards and Risks **ESS 315/POE 313**

Volcanism and Magma

Properties of Magma

-composition
-dissolved gases
-temperature
-viscosity

Eruptive Styles

Nonexplosive Eruptions

Explosive Eruptions

Volcanoes and Plate Tectonics

Shield Volcanoes

Strato Volcanoes

Pyroclastic Cones

Other Features

Volcanic Hazards

Primary Effects

-lava flows
-pyroclastic eruptions
-poisonous gas emissions

Secondary Effects

-mudflows and debris avalanches
-flooding (glacial outburst floods)
-tsunamis
-seismicity
-atmospheric effects and climate change

Volcanic Hazards along the Cascadia Subduction Zone

Predicting Eruptions

Monitoring the Movement of Magma

-seismic studies
-magnetic field changes
-electrical resistivity

Physical Anomalies and Precursor Phenomena

-ground deformation
-change in heat output
-change in the composition of gases
-local seismic activity

Outline #4 Soils in the Environment ESS 315/POE 313

Soils: the term soil has different meanings to different fields of study. All scientists agree that the carrying capacity of the Earth depends on the availabilty and productivity of soil.

Soil Formation
- -mechanical weathering
- -chemical weathering
- -rate of weathering

Soil Profile and Soil Forming Factors (Genesis and Morphology)
- **-**horizonation
- -Clorpt
- -soil classification

Describing Soil Properties in the Field
- **-**SCS Classification Criteria
- -Soil Surveys

Soil Erosion
- -Processes (rain splash, sheet erosion, rilling, gullying)
- -Estimation of Soil Loss (The Universal Soil Loss Equation)

A = RKLSCP

where:
- **A** is the average annual loss of soil
- **R** is the rainfall erosivity (total kin energy and max 30 min intensity)
- **K** is the soil erodibility factor
- **L** is the slope length factor
- **S** is the slope gradient factor
- **C** is the cropping management factor
- **P** is the erosion control practice factor

Mitigation of Soil Erosion
- -terracing
- -strip cropping
- -crop rotation
- -conservation tillage

Other Problem Soils
- -expansive soils
- -permafrost
- -settlement
- -hardening of laterites
- -salinization and waterlogging
- -hardpans and indurated horizons

Contaminated Soils
- -bioremediation
- -vapor extraction
- -phytoremediation

Outline #5 Masswasting ESS 315/POE 313

Mass wasting: movement of regolith downslope by gravity.
-does not require a transporting medium, such as water, wind, or ice.
-although water does not act directly in transporting regolith, it is still important to slope failure because it reduces friction between rock particles.
-all mass wasting processes occur on slopes.

Shear Strength (ability to resist deformation or fracture without failure)
- **-**angle of internal friction
- -effective normal stress
- -cohesion

Gravity Component
- -perpendicular component (normal stress)
- -tangential component (constitutes shear stress)

Safety Factor = shear strength/shear stress
$W.\sin\beta + V = c_j + (W.\cos\beta - u) \tan\phi$

Mass Wasting Processes
Slope Failures:
- -Slumps
- -Rock and debris falls
- -Rock or debris slides
- -Slide rock and Taluses

Sediment Flows
- -Factors Controlling Flow

Slurry Flows
- -Solifluction
- -Debris Flows
- -Mud Flows

Granular Flows
- **-**Creep
- -Earth Flows

Triggering of Mass-Wasting Events
- -Shocks
- -Slope Modification
- -Undercutting
- -Exceptional Precipitation
- -Volcanic Eruptions

Mass Wasting Hazards in the Pacific Northwest

Outline #6 Groundwater Hydrology ESS 315/POE 313

I. Groundwater Supply and Hydrogeological Properties

Groundwater Supply

-Global Hydrologic Cycle
-groundwater recharge = precipitation - (runoff + ET) Think about what factors influence soil infiltration?
-National Use
-Washington State Use

Location and Distribution of Groundwater

-zones of aeration, saturation and water table
-aquifers vs aquicludes
-springs

Hydrologic Properties

-porosity: ratio of the volume of pore spaces in a rock or other solid to the material's total volume.
-specific retention: ratio of volume of water retained to total volume of rock/soil
-specific yield: water yielding capacity (volume of water, after saturation, that can be drained by gravity to the total volume of the aquifer, as a percentage) drained by gravity to the total
-permeability: measure of velocity of a fluid as it flows through a porous medium. (*Darcy's Law*) Q = K x I x A ; *Q rate of flow, K hydraulic conductivity, I hydraulic gradient, A cross-sectional area*

Groundwater Storage and Management

-quantity of water stored in the basin and sustained yield
-groundwater mining: amount of water withdrawn from aquifer exceeds aquifer's sustained yield (e.g. High Plains aquifer)
-saltwater intrusion: *Ghyben-Herzberg lens*

Water Quality

-potable water standards: *(U.S. public health service)*
-dissolved substances
-pollutants

Conservation and Alternative Sources

-conservation
-desalinization
-artifical recharge

Outline #7 Runoff and Streams ESS 315/POE 313

Hydrologic Cycle
-the transport of water, evaporated from the sea, over land, its descent as preciptitation, drainage from the land and back to the sea.

How does water return to the sea?
-depression storage, infiltration water, interflow, impervious area runoff (Hotonian overland flow) saturated overland flow.

For a given drainage basin:
Q=P-ET±S Q is discharge, P- precipitation ET- evapotranspiration S-storage

Slope Effects on Runoff and Erosion: Four features of slope affect velocity and runoff, and hence, erosiveness.

(gradient, slope length, slope shape, slope aspect)

Vegetation, Soil Effects on Runoff

Rational Runoff Formula: Q=CIA
SCS Method to determine runoff: Q =Storm runoff x site area/storm duration

Steams Components
-channel and floodplain
-load (bed, suspended and dissolved)

Stream Geometry
Stream Channel
-cross-sectional shape
-long profile

Dynamics of streamflow
Factors in streamflow
-channel dimensions (width and depth)
-gradient (m/km)
- average velocity (m/sec);

Mannings Equation:
-discharge (Q = w x d x v); stream hydrograph

Changes downstream
->discharge
->width and depth
->velocity
-<gradient

Erosion by streams
-rainsplash
-overland flow (sheet erosion)
-streamflow
-downcutting, headward erosion, slope retreat

Factors Influencing Sediment Yield
-climate
-topography and geologiy
-human activity

Floods
-recurrence interval

Base level
-local vs ultimate base level
-artificial dams

The Graded Stream
-condition of equilibrium

Change in equilibrium
-longterm change in climate
-sea level changes
-tectonic uplift
-storm events

Outline #8 Energy Resources and the Environment ESS 315/POE 313

Earth Resources
Renewable, Nonrenewable, and Inexhaustible resources
Sustainable management of renewable and nonrenewable resources

Resource Limitations and Population Growth
Population Growth
Carrying Capacity
Support Squares

$$L = \frac{R + E + 1}{Population}$$

Fossil Fuel Energy Resources
Petroleum and Gas
- -origin and accumulation
- -geologic traps (structural, stratigraphic, salt dome, and coral reefs)
- -distribution
- -oil production
- -future reserves

Coal and Peat
- -coalification
- -reserves and production

Nonconventional Fossil Fuels
- -oil shales and tar sands

Environmental Impacts of Fossil Fuel Use
Increasing Atmospheric CO_2
Oil Spills
Strip Mining of Coal Deposits
Sulfur Emissions and Acid Rain

Future Energy Demands
Global Energy Use Patterns

Alternative Energy Resources
Solar Energy
Wind Energy
Tidal Energy
Hydroelectric Energy
Geothermal Energy
Nuclear Energy

Outline #9 Atmospheric Change ESS 315/POE 313

Structure and Composition of the Atmosphere
- **Vertical Structure**
- **Evolution of the Atmosphere**
  - **-role of volcanism**
  - **-role of life**

Spatial Variability of the Earth's Climate
- **Winds and Atmospheric Circulation**
- **Oceanic Circulation**

Natural Climate Change
- **Proxies of Climate Change in the Geologic Record**
- **Tectonism and Climate Change**
  - **The Great Ice Ages**
- **Glacial-Interglacial Cycles**
- **Short-Term Climatic Fluctuations**
  - **The Little Ice Age**
  - **Volcanism and Climatic Change**

Anthropogenic Effects on the Atmosphere
- **Recent Atmospheric Trends**
- **Impacts**
  - **Smog**
  - **Acid Precipitation**
  - **Depletion of Stratospheric Ozone**
- **Global Warming**
  - **Greenhouse Gases**
  - **General Circulation Models**
- **Responding to Global Change**